Chinese Cabbage

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Scientific Name and Introduction: *Brassica rapa* L. (*B. campestris* L.) subsp. *pekinensis* (Lour.) Hanelt, Chinese cabbage, is an annual of the Brassicaceae (Cruciferae) family (Munro and Small, 1997). The edible portion includes the leaf blades and stalks. Chinese cabbage can be divided into various head shapes, the two most common being the Nappa-type, which is short and broad, and the celery cabbage-type (Michili-type), which is long and tapered (Wang and Cerkauskas, 1999). Chinese cabbage is grown in small acreages in most major temperate vegetable growing areas and is available year-round in most markets.

Quality Characteristics and Criteria: Chinese cabbage should have uniform, tightly-formed heads with yellow-green, crinkly leaf blades. Head shape and leaf characteristics can vary, depending on the cultivar. There should be no evidence of leaf wilting or discoloration.

Horticultural Maturity Indices: Determination of maturity in species of *Brassica* is not simple and no single index of maturity is reliable (Ludford and Isenberg, 1987). Harvesting consists of cutting the whole plant at the soil surface when the heads are firm and the outer leaves are bright green (Munro and Small, 1997). With some cultivars, the outer leaves may be tied a few weeks before harvest to promote a tighter, upright head. Ludford and Isenberg (1987) cite reports that Chinese cabbage store better when heads are more compact at harvest.

Grades, Sizes and Packaging: There are no published U.S. Standards for grades of Chinese cabbage. Chinese cabbage, which can range in size from 1 to 4.5 kg (2.2 to 9.9 lb) (Watanabe, 1981), is shipped in wax-coated corrugated cardboard cartons and wire-bound crates of various sizes, depending on the shipper (http://www.ams.usda.gov/mnreports).

Pre-cooling Conditions: Any damaged leaves should be removed, the heads packed into shipping containers and quickly cooled (vacuum- or hydro-vac cooling, forced-air cooling, or hydro-cooling) to reduce senescence (Kasmire and Cantwell, 1992).

Optimum Storage Conditions: Chinese cabbage can be held in storage for 3 to 6 mo (Apeland, 1985; Kader, 1992b), depending primarily on cultivar (Fritz and Weichmann, 1980). The storage temperature should be as close as possible to 0 ºC (32 ºF) without freezing (Kasmire and Cantwell, 1992). Decay and trimming loss is reduced by storage at a RH of 98 to 100% (van den Berg, 1987). Water loss during storage can be reduced and storage-life extended if heads are stored in perforated polyethylene bags (Sozzi et al., 1981). Storage-life is extended by growing Chinese cabbage during cooler growing seasons and placing the heads upside down during storage (Jin-Cheol Jeong, personal communication).

Controlled Atmosphere (CA) Considerations: Recommended CA is 1 to 2% O_2 + 0 to 5% CO_2 (Saltveit, 1989). Elevated levels of CO_2 can increase decay and offensive odors. The harmful CO_2 concentration may be as low as 2% (Kader, 1992b) or higher, eg., > 7.5% continuously, or > 30 to 40% for 5 to 10 days (Herner, 1987). Results are variable, but 1 to 2% O_2 with CO_2 of 2 to 6% is very effective at extending storage-life of Chinese cabbage (Adamicki, 1997). Specific CA recommendations depend on cultivar, temperature and storage duration. CA storage retains green color, ascorbate and sugar content in leaves and decreases decay development (Ludford and Isenberg, 1987; Wang, 1985).

Retail Outlet Display Considerations: Chinese cabbage is displayed as individual heads with the outer leaves removed, frequently with a band around the equator to maintain a compressed head shape. Heads should be kept as cool as possible and sprinkled with water to minimize moisture loss. Exposure to ethylene should be minimized.

Chilling Sensitivity: Chinese cabbage storability may depend, in part, on cultivar differences in chilling sensitivity. Apeland (1985) reports that Chinese cabbage develops a physiological disorder (brown midrib) after prolonged storage at 0 °C (32 °F). The critical temperature for this chilling-related disorder was 1.5 to 3.0 °C (34.7 to 37.4 °F) in the three cultivars studied. A 50% loss of product may occur after about 150 degree-days below the cultivar-specific critical temperature.

Ethylene Production and Sensitivity: Chinese cabbage has a very low ethylene production rate of < 0.1 μL kg^{-1} h^{-1} at 20 °C (68 °F) (Kader, 1992a). The mean ethylene level inside cartons of Chinese cabbage in wholesale markets is 1.09 μL L^{-1} (Wills, 1998). Ethylene initiates senescence at concentrations much lower than 0.1 μL L^{-1}, and there is no benign level of ethylene in air-stored Chinese cabbage. Wang (1985) showed that the effects of ethylene, such as leaf abscission, can be minimized by storage in a 1% O_2 CA.

Respiration Rates:

Temperature	mg CO_2 kg^{-1} h^{-1}
0 °C	6 to 14
5 °C	8 to 16
10 °C	15 to 19
15 °C	19 to 30
20 °C	25 to 45

To get mL kg^{-1} h^{-1}, divide the mg kg^{-1} h^{-1} rate by 2.0 at 0 °C (32 °F), 1.9 at 10 °C (50 °F), and 1.8 at 20 °C (68 °F). To calculate heat production, multiply mg kg^{-1} h^{-1} by 220 to get BTU per ton per day or by 61 to get kcal per metric ton per day. Data are from Apeland (1985) and Cantwell and Suslow (2001).

Physiological Disorders: Brown midrib, a physiological disorder causing significant storage losses, is a symptom of chilling injury (Apeland, 1985). Elevated levels of CO_2 can increase decay and the occurrence of offensive odors (Herner, 1987).

Postharvest Pathology: Geeson (1983) reported the occurrence of leaf spots caused by *Alternaria* spp., bacterial soft rot (*Erwinia carotovora*) and black discoloration of leaf veins, which may be due to *Xanthomonas campestris*.

Quarantine Issues: None.

Suitability as Fresh-cut Product: Chinese cabbage is suitable as a fresh-cut product packaged in air or modified atmosphere packaging (MAP). Gorny (1997) rates MAP treatment as moderately effective in extending the storage-life of shredded Chinese cabbage and provides respiration rates at different temperatures, atmospheres and varying amounts of shredding (see below). More recently, Kleiber and Kim (1998) state that MAP is not essential for shredded Chinese cabbage held at 0 or 5 °C (32 or 41 °F) as there is only a transient increase in ethylene production and respiration which peaks after 6 to 12 and 0 to 3 h, respectively. The shelf-life limiting factors are browning on cut surfaces and leaf surfaces, as well as appearance of black speck (gomasho). If 1% citrate is used as a dip, a commercially acceptable shelf-life of 21 days at 0 °C (32 °F) or 14 days at 5 °C (41 °F) can be achieved without MA.

Temperature	Atmosphere	Degree of shredding	mg CO_2 kg^{-1} h^{-1}
2 °C	air	half head	10
		rough cut (0.5 x 3 cm)	18
		fine cut (0.25 - 1.5 cm)	24
5 °C	air	half head	16
		rough cut (0.5 x 3 cm)	32
		fine cut (0.25 - 1.5 cm)	40
5 °C	5 % O_2 + 5 % CO_2	half head	10
		rough cut (0.5 x 3 cm)	22
		fine cut (0.25 - 1.5 cm)	28
10 °C	air	half head	17
		rough cut (0.5 x 3 cm)	48
		fine cut (0.25 - 1.5 cm)	57
23 °C	air	half head	31 to 36
		rough cut (0.5 x 3 cm)	90 to 99
		fine cut (0.25 - 1.5 cm)	117 to 126

Special Considerations: None

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